Operant responding by bonnet macaques for color videotape recordings of social stimuli

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Socially reared juvenile bonnet macaques responded at high sustained levels in an operant task for presentation of color videotaped television images of social stimuli. Absolute levels of response depended upon the nature of the stimulus. In two experiments, subjects responded at 60.8% and 74.6% of the 1-h experimental sessions for presentation of a color videotape of a conspecific adult female moving freely in an enclosed stimulus chamber. In a later experiment, subjects maintained high levels of response during 15-min sessions for presentations of the conspecific image, but responded with significantly shorter duration responses for similar presentation of a videotape of an adult female of another macaque species, a still picture of a conspecific adult female, and a videotape of the empty stimulus chamber. With longer, 1-h, stimulus presentation, the three social stimuli sustained high levels of response while responses for presentation of the empty stimulus chamber waned significantly over the experimental session. The sustained high levels of response obtained over several hours of stimulus presentation suggest the value of color videotape stimuli in the experimental study of social perception in nonhuman primates.

Experimental studies of social choices have demonstrated that monkeys differentiate social partners along a number of socially relevant dimensions. Several early studies (e.g., Sackett, 1970) used the "self-selection circus," a multiple choice apparatus that allows subjects to demonstrate differentiation of stimulus animals through selective visual orientation and approach. With this technique, Sackett (1970) found that feral-born adult as well as 1-month-old isolate-reared rhesus macaques (*Macaca mulatta*) approached or oriented toward adult conspecifics significantly more than they did toward adults of other macaque species. In addition to differentiation of social partners along species lines, the self-selection circus has been used in various contexts to demonstrate individual recognition within the mother-infant relationship (Sackett, Griffin, Pratt, Joslyn, & Ruppenthal, 1967), preference for like-reared animals in feral and isolate-reared rhesus

monkeys (Pratt & Sackett, 1967), as well as age and gender distinctions in social partner choices by adult and young rhesus (Sackett, 1970; Sackett & Ruppenthal, 1974). This method of experimentally determining stimulus and subject parameters of social choices has provided a great deal of information about social preferences in adult and infant macaques.

Despite the seminal nature of Sackett's work, the self-selection circus suffers from two major difficulties. First, the partitions separating the subject and stimulus animals in the apparatus are transparent, allowing interaction between the two to occur. Thus, the obtained choices of social partners may have been based on any combination of behaviors of subject and stimulus animals, making the basis for these social choices indeterminate. Studies that have used one-way glass to correct this problem (e.g., Rosenblum & Alpert, 1974, 1977) are subject to the second problem inherent in previous social choice experiments. That is, the use of live animals as stimuli does not allow any standardization of the cues presented to subjects during choice trials. Such studies do not allow systematic identification of cues presented to the subject during choice trials. In order to assess and specify the social cues determining relative choices of or responses to various classes of social stimuli, not only must the potential for social interaction between subject and stimuli be removed, but

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also specifiable, replicable, social stimuli should be presented.

The use of pictures as stimuli provides such standardization. Several studies have investigated the macaque's perception of pictorial representations of social stimuli. In an early study, Sackett (1966) found that isolate-reared rhesus infants responded differentially to pictures of conspecific adults and infants. These subjects responded with play and manipulative behaviors to pictures of infants, showed fear and withdrawal in response to pictures of adult males threatening, and largely ignored other pictures of adult conspecifics. These responses were infrequent in the neonatal period, showed a sharp peak at the age of 2½-3 months, and were followed by a subsequent decline in response to all pictures. Other studies have shown that macaques spend different periods looking at and manipulating pictures as a function of their communicative content (Sackett, 1965) and the species and age of the stimulus animals (Swartz, 1977).

Not only will monkeys respond selectively to categories of pictures presented noncontingently by an experimenter, but they will also perform an operant response in order to obtain visual access to still photographs or moving pictures (Butler, 1961; Butler & Woolpy, 1963; Humphrey, 1972). Furthermore, the rates of such operant responses will vary according to the content of the pictures. Redican, Kellicutt, and Mitchell (1971), using an operant lever press response, and Haude and Detwiler (1976), employing an operant visual exploration response, found that rhesus monkeys differentiated pictures of negative social gestures (e.g., threat, grimace, submission) from pictures of other types of social gestures (e.g., "plain face," grooming). Unfortunately, although some significant differences in response levels to different categories of pictures were obtained in each of these two studies, the overall results were not conclusive, nor were they consistent across the two very similar studies. One problem common to both these studies was the relatively low rate of response, even for the stimulus categories that sustained the highest levels of responding. Although precise levels of responding were difficult to determine from Redican et al.'s (1971) report, the response levels were clearly low (they report an initial high mean response rate of 6.99%), and Haude and Detwiler's (1976) subjects spent an average of 19.56% of the experimental trials observing the stimuli. Indeed, such low rates of response with static two-dimensional stimuli are consistent with Humphrey's (1974) demonstration that rhesus monkeys' operant response levels for still photographs of monkeys and members of other, nonprimate species decreased considerably within 100 sec of stimulus presentation. In contrast, response rates for the presentation of color cartoon films or closed-

circuit black-and-white television images of conspecifics maintained high levels (70%-80%) over trials 400 to 500 sec in length (Humphrey, 1972; Humphrey & Keeble, 1976).

Despite the higher rates of responding obtained with moving pictorial stimuli, few studies have employed moving pictures as stimuli with monkey subjects, and none have systematically addressed questions of social perception. Butler and Woolpy (1963), using 16-mm films as stimuli, found that rhesus would differentiate stimuli on the basis of physical dimensions such as focal clarity, brightness, and color. In general, the animals would look longer at films that were in focus rather than out of focus, brightly illuminated rather than dim, and in color rather than black-and-white. Similarly, Humphrey (1972) demonstrated that continuous films sustained interest (operationally defined by operant response levels) over a longer period of time than did short repeated film loops.

Although Humphrey and Keeble (1976) have used closed-circuit black-and-white television images of conspecific individuals in an operant habituation paradigm to demonstrate differentiation of individuals in rhesus macaques, chromatic moving pictorial stimuli have not been used systematically to study social differentiation in monkeys. From several standpoints, the present set of experiments represents a unique contribution to the study of picture perception and the perception of social stimuli in non-human primates. First, an operant procedure was developed that allowed the presentation of color videotaped television images as stimuli. The first two experiments were designed to determine whether socially reared bonnet macaque subjects would perform an operant leverpress response for presentation of a videotape of an adult conspecific moving freely in an enclosed stimulus chamber, and to determine the durability of such responding over relatively long intervals. The second experiment further investigated the effects of repetition of stimulus information on the level of operant responding for visual presentation of a social stimulus.

The last two experiments allowed assessment of more specific aspects of the stimuli, as well as providing a direct comparison of three different dependent measures which might reflect different psychological processes. In these latter experiments, the primary question was whether socially reared bonnet macaques would differentiate a moving videotape image of a conspecific from a similar image of an individual of another macaque species. In addition, the relative importance of movement of the stimuli was addressed by comparing responses to the moving conspecific image with responses to a still photograph of a conspecific, providing the first direct comparison of response to still and moving images of the same stimulus. A control stimulus condition,

consisting of a videotape of an empty stimulus chamber, was also included to demonstrate that responses to the social stimuli were not the result simply of changes in general level of stimulation or illumination.

GENERAL METHOD

Apparatus

The operant chamber was a 35.5 × 33 × 49.5 cm plywood box painted flat black. The front of the box contained a 35.5 × 38 cm opening covered with hardware cloth. Access to the manipulandum was provided through a 6.4 × 15.2 cm opening centered at the bottom of the hardware cloth area. The manipulandum was a 12.7 × 10.2 cm modified foot switch mounted in the center of a 35.5 × 12.7 cm lighted Plexiglas panel.

Stimulus presentation, session length, and data recording were controlled by electronic equipment contained in the same room as the operant chamber. The total frequency of responses in each session was recorded on a Sodeco Model TCeZ3E impulse counter, and the total time spent pressing the manipulandum during each 15-sec interval of each session was recorded every 15 sec by a Moduprint Model B3-158 printing counter. Throughout each session, experimental room noise was masked by low-level white noise.

The stimuli were color videotapes of various social and non-social stimuli presented to the subjects on a 25-in. diagonal RCA XL-100 color television by a JVC Model CR-606U video cassette recorder. The television screen was located 66.4 cm from the front of the operant chamber, and the size of the stimulus animals displayed on the television screen ranged from 30 to 33 cm (head to rump). In all cases, the stimulus animals were strangers to the subjects.

Procedure

Each subject was tested individually, 1 h per day. In some cases, the session consisted of a continuous 1-h-long period; in other cases, the hour was divided into four discrete 15-minute segments. Approximately ½ to 1 h prior to each subject's experimental session, the subject was removed from the social group and put in a carrying cage that was placed in an undisturbed part of the laboratory. When the apparatus was ready, the subject was transported in the carrying cage to the experimental room, where it was allowed to enter the operant chamber through a rear guillotine door. Throughout the experimental session, the room was darkened. At the beginning of each session (or 15-min segment), the manipulandum was inoperative and the animal was provided with a 10-sec noncontingent presentation of the stimulus. Following this 10-sec preview, the response panel was illuminated and stimulus presentation was contingent upon pressing of the manipulandum. The tape recorder was running continuously throughout the session, so that whenever a subject pressed the manipulandum, the segment of the tape that was presented was not necessarily continuous with that shown during the previous response. The stimulus was presented for the entire duration of a press; during stimulus presentation the lights in the response panel were turned off. When no response was being made, the Plexiglas panels on both sides of the manipulandum were illuminated by a 24-V white bulb and the television screen was blank (the television was turned on and the screen was dimly illuminated, but no picture was available). At the end of each session (or 15-min segment), the apparatus was automatically shut off, the subject's view of the blank television screen was blocked by an opaque partition placed over the hardware cloth opening in the operant chamber, and the room lights were turned on. At the end of the hour, the subject was removed from the operant chamber and returned to its home pen.

EXPERIMENT 1

The initial experiment was designed to determine, first, whether young, socially reared bonnet macaques would perform an operant response for presentation of a color videotape of a conspecific adult female and, second, whether this response would change as a function of experience with the stimulus over three relatively long (1-h) stimulus sessions.

Method

Subjects. The subjects were six 2-year-old laboratory-born bonnet macaques (*Macaca radiata*), five females and one male. Prior to the beginning of the present experiment, all animals had had similar social rearing histories, consisting from birth of conspecific social group experience with their mothers, age peers, and other adult conspecific females. At the time of the study, all subjects were housed in social groups with their mothers and three or four age peers and their respective mothers.

Immediately prior to the beginning of the first formal study, all subjects had participated in several preexperimental training sessions involving operant responding for presentation of black-and-white videotapes of social stimuli. Thus, all subjects were equally experienced with the apparatus and procedure of the present study and all had previously been trained to perform the required operant response for presentation of videotapes of social stimuli.

Stimuli. The stimulus was a one-hour color videotape of an adult female bonnet macaque moving about in an enclosed 60.3 × 71.1 cm stimulus chamber. Although the tape was not edited in order to include or eliminate particular behavioral sequences, it was previewed before the experiment to ensure that its content was not atypical of the behavior patterns of the bonnet macaque and that its quality did not change significantly as a function of time. Throughout the tape, the stimulus animal was moderately active, not agitated, and spent most of her time manually and visually exploring the stimulus chamber. Although the stimulus animal occasionally turned her back to the camera, such a posture occurred only rarely, and her primary orientation was toward the front of the stimulus chamber.

Procedure. Each animal was tested in a continuous 60-min session each day for 3 days. The same 1-h-long stimulus tape was shown to all subjects.

Results

Three dependent measures were obtained in each stimulus session: total frequency of response during each 1-h session, proportion of the total trial length spent pressing the manipulandum, and mean response duration (obtained by dividing the total response time in seconds by the total frequency of response).

An initial summary of each individual subject's performance in the present procedure showed that, with one exception, all subjects spent over 50% of the time in the operant chamber pressing the manipulandum. The mean response levels (percentage of time spent responding) for each subject were, respectively, 20.1, 51.4, 66.0, 70.4, 76.3, and 80.6. Response frequencies were high (86.7, 158.7, 243.0, 178.0, 137.0, and 130.0, respectively, for the individual subjects), resulting in mean response durations of 8.4, 11.7, 9.8, 14.2, 20.0, and 22.3 sec, respectively, for each subject.

Table 1
Mean Response Levels for Presentation of a Videotape of a Conspecific Adult Female

Experiment	Number of Sessions	Length of Sessions	N	Response					
				Percentage		Frequency		Duration (in Seconds)	
				Mean	SD	Mean	SD	Mean	SD
1	3	1 h	6	60.8	22.4	155.6*	52.7	14.4	5.7
2	5	1 h	4	74.6	6.0	26.3**	8.5	39.6	21.7
3	4	15 min	4	78.8	19.4	12.8**	10.0	166.2	89.8
4	4	15 min	4	89.3	9.9	11.6**	5.5	124.4	77.0

Note—The mean duration score reported in this table is not equal to the mean time score divided by the mean frequency since the function relating these variables on the individual level is multiplicative in nature [i.e., $\text{duration} = (\text{time})/(\text{frequency})$, where $\text{time} = (\text{percentage of time spent responding})/(\text{session length})$]. *Mean frequency for 1 h of stimulus presentation. **Mean frequency for 15 min of stimulus presentation.

The results of a repeated measures analysis of variance showed no effect of days on frequency of responding or on response duration. Table 1 presents a summary of response levels on the three dependent measures for presentation of the videotape image of a conspecific adult female across all four experiments of the present series.

The data from the proportion of trial time spent responding were transformed by an arcsin transform (Winer, 1962) and analyzed by a 3 (days) by 4 (15-min segments) repeated measures analysis of variance to determine whether there were any changes in time spent responding as a function of days (sessions) or time within sessions (15-min segments). The results of this analysis indicated that there was no significant effect of days or segments and no significant interaction. Figure 1 presents the mean percentage of time spent responding for presentation of the videotape of a conspecific adult female, in 15-min intervals. The first panel presents mean response levels, from the six subjects, to the preexperimental training stimulus, a black-and-white videotape of a different bonnet female, over three daily sessions of 15 min each. The proportion data from Experiment 1 are shown as percentages in the second panel. These data are all presented as overall means from 15-min blocks of stimulus presentation; however, the daily sessions in Experiments 1 and 2 were 1 h in length. The arrows in the figure demarcate daily sessions. As Figure 1 demonstrates, there was a significant increase ($p < .05$) in response levels when the stimuli were shifted from black-and-white to color, and response levels to color stimuli remained at a high level throughout several hours of stimulus presentation.

Discussion

The results of the first study demonstrated that in an operant setting young bonnet macaques would maintain consistently high levels of response to obtain visual access to a color videotape of a conspecific adult female. Not only were the overall response levels high (overall mean = 60.8%), but

there was no indication of a response decline, either within or across sessions. These high, sustained levels of response are particularly striking in comparison to previously obtained data from rhesus macaques in similar experimental procedures using static two-dimensional visual stimuli. In such studies (e.g., Humphrey, 1972, 1974), high levels of operant response for presentation of pictures of social and nonsocial stimuli rapidly waned over 100 to 200 sec of stimulus presentation.

Although some previous studies have reported high levels of operant responding for moving pictorial stimuli, the results of such experiments were obtained with relatively short stimulus presentation sessions, unlike the relatively long sessions employed in the present experiment. For example, although Butler (1961) obtained levels of 61.7% and 81.3% with a door-opening response in rhesus for visual access to two color films of conspecifics, the session lengths in his experiment were 22 and 9 min, respectively, and each film was presented only once. Similarly, Humphrey and Keeble (1976) obtained leverpressing responses in rhesus monkeys that averaged approximately 70%-80% for presentation

Figure 1. Mean percentage of time spent responding for presentation of a color television image of a conspecific adult female. Each point represents one 15-min segment of stimulus availability. The arrows demarcate each day within each experiment. The data from the black-and-white stimulus presentation were collected over three daily 15-min sessions of stimulus presentation.

of closed-circuit black-and-white television images of an adult conspecific and Humphrey (1972) obtained response levels of 80%-90% for presentation of color animated cartoons; however, in both experiments the experimental sessions were only 6.7 to 8.3 min (400 to 500 sec) in length. No prior experiments have employed stimulus sessions as long as those in the present experiment. The consistently high levels of response obtained in the present experiment suggest that color videotaped images of conspecific social partners are very potent stimuli for the macaque subject.

EXPERIMENT 2

In view of previous studies of operant viewing patterns in monkeys, the sustained high levels of response obtained over three 1-h sessions of stimulus presentation in Experiment 1 were somewhat unexpected. Possibly relevant to this set of results is Humphrey's (1972) finding that repeating film loops were viewed initially at high rates but did not sustain the same level of response over time as continuously changing films. One explanation for the consistently high levels of responding in Experiment 1 might relate to the continuously changing nature of the hour-long stimulus tape. In order to determine whether this continuous change was necessary to sustain high levels of operant responding for presentation of a videotaped social image, a second experiment was performed in which the hour-long test session was divided into four 15-min segments during which the same 15-min videotape segment was presented four times. Thus, if the high response levels obtained in Experiment 1 were sustained primarily by the constantly changing behavior of the stimulus animal, it would be expected that repetition of the same 15-min videotape segment across experimental sessions and across days should result in a decline in response level either across time within each day or across days.

Method

Subjects. Four subjects from Experiment 1, three females and one male, were chosen as subjects on the basis of their high response levels during that experiment. The two subjects with the lowest overall response levels were eliminated from the present and subsequent studies.¹

Stimuli. Fifteen-minute videotapes of each of two adult female bonnet macaques were used as stimuli. With the exception of the individuals videotaped, these two tapes were identical to the stimulus tape presented in Experiment 1. The two stimulus tapes were used in the present study in order to ensure that response levels were not specific to a particular stimulus animal's behavior. Two subjects were chosen randomly to see stimulus animal A, while the other two were presented with stimulus animal B throughout the course of the study.

Procedure. Each animal was tested 1 h per day for 5 days. The hour-long stimulus session was divided into four 15-min segments,

each separated by a 1- to 2-min interval during which the stimulus tape was rewound. During this interstimulus interval, the apparatus was inoperative and the room lights were turned on but the animal remained in the operant chamber.

Results

As shown in the third panel of Figure 1, the percentage of trial time spent responding in the present study was, as in Experiment 1, high and consistent across 15-min segments within each 1-h session, as well as across days. A 4 (15-min segments) by 5 (days) repeated measures analysis of variance of the arcsin transformed proportions showed that there was no effect of either days or segments on this measure and no interaction. The frequency and mean duration measures (summarized in Table 1) were similarly analyzed, and no significant effects were obtained with the mean response duration measure. The analysis of the frequency measure showed only a significant segments effect [$F(3,9) = 4.47, p < .05$]. The mean frequency of response for each of the four 15-min segments was, in order, 35.5, 24.0, 23.9, and 21.8. A post hoc comparison of these means using the Newman-Keuls method indicated that the frequency of response during the first segment was significantly higher than that of the fourth segment ($p < .05$); no other means differed.

Discussion

The results of Experiment 2 demonstrated that even when the stimulus was repetitive, the presentation of color videotapes of a conspecific sustained high levels of operant responding over a relatively long period of stimulus presentation. There was no evidence of response waning over the 5 h of stimulus availability on either the mean response duration measure or the percentage of time spent responding. The significant drop in response frequency from the first to the fourth segment of the stimulus session, combined with no decline in proportion of time spent responding, suggests that the subjects were holding the lever longer with each press as the session continued. Indeed, the mean duration of response rose from 27.6 sec in Segment 1 to 40.9 sec in Segment 4, although this difference was not statistically significant. Such a trend from short, frequent responses to longer, less frequent responses may reflect more efficient responding and should indicate a growing interest in the stimulus rather than a decline in interest. Butler (1961; Butler & Woolpy, 1963) found similar changes in response patterns with repeated stimulus presentation. Thus, even with increased repetition of the stimulus, the previously obtained high levels of response for the presentation of a videotape of a conspecific adult female were upheld in the present experiment.

EXPERIMENT 3

The results of the previous two experiments demonstrated that bonnet macaques would respond at high operant levels for presentation of color videotapes of a conspecific adult female. The question still remains as to whether these response levels were affected by the nature of the social information presented in the stimulus tape. To address this issue, a third experiment was conducted in which the nature of the social stimuli presented in the videotapes was varied. Three major questions were addressed in the present experiment. The first question was whether the subjects would differentiate the social stimuli along meaningful social lines, such as species. Thus, in addition to a videotape of a conspecific adult female, a similar videotape of a pigtail macaque (*M. nemestrina*) adult female was presented. A second question was addressed to the movement qualities of the conspecific social stimulus by asking whether the subjects would differentiate a static two-dimensional representation of an adult female conspecific from a moving two-dimensional representation of the same class of social stimulus. The third stimulus, then, was a videotape recording of a still photograph of an adult bonnet female. Finally, as a control for diverse perceptual stimulus qualities such as complexity and illumination, a videotape of the empty stimulus chamber was presented as a fourth stimulus.

Method

Subjects. The same four subjects who participated in Experiment 2 served as subjects in the present experiment.

Stimuli. The moving-bonnet-female tapes were the same two 15-min tapes used in Experiment 2. Those animals who had previously seen stimulus animal A were presented with stimulus animal B, and vice versa. Only one videotape of a pigtail adult female was used. This tape was similar in method of recording and in overall behavioral content to the tapes of the bonnet females. The nonmoving-bonnet stimulus tape was obtained by videotaping the projected image of a slide of an adult bonnet female sitting in a stimulus chamber the same size as that of the moving stimuli but with a dark background. The videotaped still image of the bonnet female was the same size as the moving bonnet images. The fourth stimulus was a videotape of the stimulus chamber recorded with all conditions identical to those of the moving animal recordings, with the exception that no animal appeared in the box. All tapes were 15 min in length.

Procedure. Each of the four stimuli was presented to each subject once a day for 4 consecutive days in a balanced Latin-square order. Each stimulus was available for 15 min, with a 10-sec preview period and a 1-to 2-min intertrial interval.

Results

Table 2 presents a summary of mean response levels on all three dependent measures for presentation of moving pigtail female, the photograph of the bonnet, and the empty stimulus chamber. These data can be compared with the same measures of response for the moving bonnet female presented in Table 1.

Table 2
Mean Overall Response Levels for Stimulus Presentation
in Experiments 3 and 4

	Response					
	Percentage		Frequency		Duration (in Seconds)	
	Mean	SD	Mean	SD	Mean	SD
Experiment 3						
Bonnet Female	78.8	19.4	12.8	10.0	166.2	89.8
Pigtail Female	70.7	12.3	18.2	10.3	62.4	37.3
Still Bonnet	73.3	10.5	16.6	10.8	80.8	71.9
Empty Chamber	68.3	9.1	17.4	6.0	50.1	24.0
Experiment 4						
Bonnet Female	89.3	9.9	11.6	5.5	124.4	77.0
Pigtail Female	89.7	9.2	11.9	8.0	157.0	157.2
Still Bonnet	67.6	30.0	12.4	4.8	128.9	183.2
Empty Chamber	35.5	18.3	8.9	4.8	32.5	18.2

Note—The mean duration score reported in this table is not equal to the mean time score divided by the mean frequency since the function relating these variables on the individual level is multiplicative in nature [i.e., $\text{duration} = (\text{time}) / (1/\text{frequency})$, where $\text{time} = (\text{percentage of time spent responding}) / (\text{session length})$].

Each of the three dependent measures was subjected to a 4 (stimuli) by 4 (days) repeated measures analysis of variance. The analyses of the transformed proportions and of the frequency measure showed no significant effects of stimuli or days, or any interaction.

Mean response duration, however, did show a significant main effect of stimuli [$F(3,9) = 4.76$, $p < .05$], but no effect of days and no interaction. As Figure 2 demonstrates, a post hoc analysis of the stimulus effect using a Newman-Keuls procedure indicated that responses were significantly longer for presentation of the moving conspecific (bonnet female) than they were for presentation of the moving non-

Figure 2. Mean duration of response for each stimulus in Experiment 2. MC = moving conspecific (bonnet female); MN = moving nonconspecific (pigtail female); PC = still picture of conspecific; EC = empty stimulus chamber.

conspecific (pigtail female), the still conspecific (photograph of bonnet female), or the empty stimulus chamber, and there were no differences across these latter three stimuli.

Discussion

The results of the present experiment indicated that socially experienced subjects would differentiate a videotape image of a conspecific from a similar image of a member of another species. In addition, presentation of a static conspecific image was not as effective as presentation of the moving conspecific image, nor was the image of an empty stimulus chamber. These results suggest that the nature of the social information presented in the videotape stimuli is, in fact, important in maintaining high levels of responding in these subjects. Moving stimuli were differentiated along the lines of species, and, holding species constant, a moving stimulus was preferred to a still. It should be noted that the moving conspecific stimulus differed from the still conspecific stimulus in aspects other than simple motion. Such factors as variety of expression, relative activity, and changes in posture differentiate animate from inanimate social stimuli, and any combination of these or other motion-related factors could be the basis for the obtained differentiation. Although the question of what specific variables contributed to this differentiation remains open, the major purpose for the inclusion of the still photograph was to determine whether moving and nonmoving representations of the same class of social stimulus would be differentiated in the operant procedure of the present studies. That result obtained, the determination of what specific movement-related cues contributed to the obtained differentiation is left for future research. Finally, it is clear from the response levels for presentation of the empty stimulus chamber that the high levels of responding obtained in Experiments 1 and 2 for presentation of the moving conspecific were related to the nature of the stimulus pictured, and that they were not the result solely of some tendency to illuminate the darkened operant chamber.

The obtained differentiation occurred with the mean response duration measure, suggesting that, although the subjects were pressing the lever for stimulus presentation at about equal frequencies for each of the stimuli, when a response resulted in presentation of the conspecific female, the lever was held down longer during that stimulus than it was during the presentation of other stimuli. Thus, although all the stimuli supported relatively high levels of response (68%-78% of each session), the tape of the conspecific adult female appeared to sustain more interest, reflected by longer responses, once it appeared on the screen.

EXPERIMENT 4

Although the results of Experiment 3 demonstrated that monkeys would differentiate a videotape of a moving conspecific from other social stimuli in the operant procedure, the failure to obtain significant differentiation of an empty stimulus chamber from these other social stimuli presents a problem of interpretation. The relatively high level of response to the tape of the empty stimulus chamber may have been obtained simply because the empty stimulus chamber was complex enough to be more interesting to the subjects than the homogeneous blank television picture and, hence, elicited a certain level of response in its own right. If this explanation forms the basis for the level of response obtained for presentation of the empty stimulus chamber in Experiment 3, it would be expected that, with further experience with the stimuli, responding for the presentation of that stimulus should wane sooner than responding for the more complex social stimuli. The purpose of the present experiment, then, was to determine whether responding for presentation of the empty stimulus chamber would wane after lengthy exposure to that stimulus or whether it would maintain the same response levels as did the social stimuli.

Method

Subjects. The subjects were the same four subjects that were included in Experiments 2 and 3.

Stimuli. The stimuli were the same five 15-min stimulus tapes used in Experiment 3: two tapes of a moving adult bonnet female (each subject saw the same bonnet female tape presented in Experiment 3), one tape each of a moving adult pigtail female, a still picture of an adult bonnet female, and the empty stimulus chamber.

Procedure. The subjects were tested for 1 h on each of 4 consecutive days, with only one stimulus presented each day. Each session was divided into four consecutive 15-min segments of stimulus presentation, with the same stimulus repeated four times. On a particular day, each subject saw a different stimulus. Order of stimulus presentation across subjects and across days was balanced in a Latin-square design.

Results

The three dependent measures were each analyzed by a 4 (stimuli) by 4 (15-min segments) analysis of variance with repeated measures. The analysis of the mean duration measure showed no effect of stimuli, time segments, or interaction. The frequency measure showed only a significant main effect of segments [$F(3,9) = 3.88$, $p < .05$], with mean frequency of responding in Segments 1 through 4, respectively, equal to 14.9, 10.9, 11.1, and 8.0. Post hoc Newman-Keuls comparisons showed that the frequency of response in the first segment was significantly higher than the frequency during the fourth segment ($p < .05$); no other differences were significant. The

analysis of the transformed proportion data showed significant main effects of stimuli [$F(3,9) = 6.86$, $p < .01$] and segments [$F(3,9) = 10.92$, $p < .01$], as well as a significant Stimulus by Segments interaction [$F(9,27) = 4.38$, $p < .001$]. Post hoc analysis of the interaction indicated that the response levels for all four stimuli were equivalent during the first 15-min segment but that the response for the empty stimulus chamber dropped off significantly during the second, third, and fourth segments. Response levels for the three other stimuli did not differ from one another throughout the four segments; these results are shown in Figure 3.

Discussion

The results of the present study indicated that nonsocial stimuli were differentiated from social stimuli in an operant setting, but only after an extended period of stimulus presentation. It appears that, in the procedure employed in the present set of experiments, even a picture of an empty stimulus chamber was sufficiently interesting to support relatively high levels of response during a 15-min period. If the videotape of the empty chamber can be conceptualized as being similar to (if not the same as) a still picture of the stimulus setting, then the finding of high levels of response for presentation of that stimulus stands in direct contrast to previous findings of rapid waning of response for still pictures, even pictures of social stimuli (Butler, 1961; Butler & Woolpy, 1963; Humphrey, 1972, 1974). Indeed, the high levels of response obtained in Experiments 3 and 4 for presentation of the still picture of a bonnet female are also surprising in the context of previous results. Clearly, the moving color video image of a

conspecific adult female was a very potent stimulus for the subjects in the present set of studies, maintaining high consistent levels of operant responding over several hours of stimulus presentation. One possible explanation for the initially high levels of response for the empty stimulus chamber may be related to stimulus generalization, or the buildup of some set of expectations, carrying over from the moving image of the bonnet female. Thus, the picture of the empty stimulus chamber may have sustained high levels of response by virtue not of its own inherent interest to the subjects, but rather by its similarity to a stimulus that was inherently interesting. In the absence of temporally adjacent exposure to the social stimulus and with extended exposure to the empty chamber, response levels for this nonsocial inanimate stimulus decreased significantly. The social content of a still picture was clearly relevant to the subjects, as indicated by the finding that response levels for the still photograph of a bonnet female did not significantly decline in the same situation.

Also noteworthy in the results of the present study was the finding that, in contrast to the results of Experiment 3, response levels for the presentation of the moving bonnet female were not significantly higher than those for presentation of the moving pigtail or the still picture of the bonnet. This lack of differentiation resulted from an increase in response levels for presentation of the latter two stimuli rather than a decrease in response for the moving bonnet female. A probable explanation for the obtained rise in response level to two previously less preferred social stimuli, and the consequent failure to replicate the previously obtained differentiation of social stimuli, may be related to procedural differences across Experiments 3 and 4. In Experiment 3, in which differentiation of social stimuli occurred, all four stimuli were presented to each subject within each session, thus potentially allowing some comparisons across stimuli to be made on the basis of memory within a relatively short time period. In Experiment 4, no such short-term memorial comparisons across stimuli could be made, since only one stimulus was presented on a given day. Thus, in the absence of the most potent social stimulus (the moving conspecific) as a comparison, other, less effective social stimuli may have sustained high levels of response. This suggestion is consistent with the idea that, in the present situation, some stimuli (i.e., the picture of the empty stimulus chamber) may sustain high levels of responding over short periods of time (i.e., 15 min) but eventually result in response decreases; similarly, it may be that some social stimuli might be quite effective when presented alone but less effective when presented along with other more potent stimuli. A previous study using live animals as stimuli obtained such a result. Rosenblum and Alpert

Figure 3. Percent of time spent responding for presentation of each of four stimuli across the four segments of a 1-h session in Experiment 4. MC = moving conspecific; MN = moving nonconspecific; PC = still picture of conspecific; EC = empty stimulus chamber.

(1974) found that, when given a choice between the mother and an unfamiliar conspecific adult female, infant bonnet macaques would choose the mother and avoid the unfamiliar female. However, when the unfamiliar female was presented alone, the infants would approach and maintain proximity to her. Thus, the patterns of response to various types of stimuli may be related to temporal and procedural factors in the experimental paradigm used as well as to specific content of the stimuli in question.

An additional question that should be empirically addressed in future studies is the role of experience with two-dimensional stimuli in determining rate or patterns of response in experimental settings. Since most nonhuman primates have little experience with two-dimensional representations of social partners, their patterns of response to such stimuli might be expected to shift across time as they extract different types or degrees of information from the two-dimensional stimulus array. That is, it may be that naive subjects must learn how to extract information from pictures and may therefore show varying levels of discriminative capacity, depending on the amount of experience with pictures (Deregowski, Muldrow, & Muldrow, 1972). Such varying levels of discrimination might be reflected in absolute response levels or in overall response patterns. The present set of experiments does not allow an empirical assessment of this notion, since experience with pictures was confounded with the introduction of new stimulus conditions. It should be noted, however, that the response pattern for the presentation of the conspecific female did not show a statistically reliable change with increasing experience over the four experiments.

In comparing the results of the present set of experiments to previous findings, one major issue has been ignored. Although all previous studies have used rhesus macaques as subjects, the present experiments used bonnet macaques. Profound species differences have previously been reported in experimental and observational comparisons of social behavior in bonnet and pigtail macaques (e.g., Rosenblum, 1971; Rosenblum, Kaufman, & Stynes, 1964). Bonnet macaques typically spend more time in close physical and social contact with other group members than do pigtail macaques. Although explicit comparisons between rhesus and bonnet macaques have not been reported, published reports of rhesus social behavior (e.g., Harlow & Harlow, 1965; Hinde, 1971) would suggest that similar differences would be found between rhesus and bonnets. The question then becomes whether these species differences alone can account for the high levels of operant responding for social stimuli found in the present studies with bonnet macaques as subjects, as opposed to the low levels of response found previously with rhesus macaques. Unfortunately, since the species variable was confounded with the procedural changes incor-

porated in the present studies, an answer to that question is currently unavailable. As a function of their tendency to maintain close physical contact with other group members, bonnet macaques might be more motivated to obtain visual contact with conspecifics and hence might show higher levels of operant responding for such visual stimuli. The degree to which such species variables determine responding in the experimental operant setting remains an open empirical question; however, to the extent that such variables operate to influence absolute rates of responding, this underscores the sensitivity of the experimental operant procedure as a method for exploring social choice and other social variables in macaque species.

A final issue raised by the results of the present set of experiments relates to patterns of responding and the functional relationship between the three response measures employed in these experiments. Although the three measures are clearly not independent of one another, they may reflect different aspects of the process of stimulus differentiation, either individually or as unique integrated patterns. For example, two stimuli may not be differentiated in terms of percentage of time spent responding, but the pattern of response for stimulus A might consist of a few long-duration responses while the pattern for stimulus B might consist of several short-duration responses. Such a finding presumably would reflect qualitative differences in the subject's perception of the stimuli such that stimulus A might be considered to be more interesting or more "attention holding" (Cohen, 1972) than stimulus B. The stimulus differentiation obtained in Experiment 3 was of this nature, as was the stimulus differentiation reported by Butler (1961) in a study that compared rhesus monkeys' door-opening responses to films of conspecifics, animated cartoons, and still photographs. Similarly, in another experiment comparing rhesus monkeys' responsiveness to various types of static and moving pictorial stimuli, Butler and Woolpy (1963) found that their response frequency measure generally did not reflect stimulus differentiation, whereas the total time and mean response duration measures did demonstrate differentiation of pairs of stimuli. The relationships among these various response measures, and the implications of particular patterns of responding have not been explored with pictorial stimuli, although Haude, Kruper, and Patton (1966) did attempt to determine the relationships among various operant measures of visual exploration in rhesus monkeys using three-dimensional stimuli. They found that, in experimental procedures in which the subject could control the duration of an instrumental response for access to a visual stimulus, the response duration measure reflected stimulus differences but the frequency measure did not. In a comparison of actual time spent looking at

a stimulus with other types of instrumental responding, Haude et al. found that looking and instrumental responding were correlated but that they did not show the same patterns of statistical differentiation of stimuli. Their conclusion was that, depending on the nature of the response, stimulus differentiation might be reflected by different measures. For example, both frequency and duration measures might reflect stimulus differentiation with an instrumental looking response, but with other, more manual, forms of instrumental responding a frequency measure might be less sensitive. As before, the results of the present set of studies suggest the necessity for such considerations, but they do not allow an empirical assessment of the issues raised regarding the relationships among the various dependent measures of responsiveness to pictorial social stimuli. Indeed, one major question suggested by the Haude et al. (1966) data and not addressed in the present set of experiments is the extent to which the subject was actually watching the television screen during stimulus presentation. Although the operant chamber and the manipulandum were constructed to minimize the opportunity for the subjects to engage in other activities during stimulus presentation, the possibility does remain that they were not constantly attending to the visual stimuli during stimulus presentation. Clearly, the obtained stimulus differentiation suggests that subjects were attending to the stimuli enough to make meaningful discriminations across various types of stimuli. In addition, informal observations of the subjects' behaviors during the course of the experiment, including some closed-circuit monitoring of subjects during stimulus presentation, suggested that they spent a large proportion of stimulus presentation time actually observing the stimulus available on the television screen. These response measurement issues, particularly the relationship between looking patterns and operant responses for pictorial stimulus presentation, are issues that must be attended to empirically in subsequent studies of social perception in nonhuman primates.

CONCLUSIONS

The present set of studies represents the first use of color videotaped social stimuli in an operant setting with macaque subjects. The sustained high levels of response for presentation of a moving image of a conspecific adult female, obtained over several days with long stimulus sessions, demonstrate the effectiveness of such stimuli with nonhuman primate subjects. In addition, the obtained differentiation of stimuli along social (species) and non-social (movement) dimensions suggests that the combined operant response videotape stimulus method described in the present experiments can

be usefully employed in experimental studies of social differentiation and preference with macaques. In particular, such a procedure could very effectively be used in asking questions related to species recognition and differentiation of social partners (e.g., recognition of the mother) in very young animals that do not yet efficiently locomote. The procedure is also clearly useful in cases in which the stimulus information accessible to the subject (or to a group of subjects) should be well controlled and quantified. The use of videotaped images provides a realistic social stimulus that is also indefinitely reproducible and objectively quantifiable; the use of an operant presentation technique allows precise assessment and specification of response patterns. Used effectively, the present technique can provide a wide range of information regarding the determinants and the ontogeny of various aspects of nonhuman primate social behavior.

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NOTE

1. The two subjects were eliminated for practical reasons related to amount of experimental apparatus time available for Experiment 2; they were not eliminated for failure to respond, as the presentation of individual subject data in the previous Results section indicates. Although eliminating the two subjects with the previously lowest response levels biases the results of the current study in favor of higher response levels, the prediction of the present study was that response levels would decrease with repetition of stimulus information; consequently, absolute levels of response should be irrelevant in observing the expected result.

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